BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B69 09046

SUBJECT: A Possible VHF Backup Communications Between Extravehicular Astronauts on the Lunar Surface and the Earth - Case 320

DATE: September 19, 1969

FROM: R. L. Selden

ABSTRACT

A performance analysis of the communications that could be obtained between the Earth and an astronaut on the lunar surface using the existing extravehicular communications system shows that VHF voice to the astronauts and a VHF key mode from the astronaut is feasible. The earth based VHF station could consist of a 60 foot diameter antenna system and a one kilowatt transmitter. This communications configuration would require very little or no change to the existing backpack communications system and could be used either as a backup system to normal communications modes or as a minimal link anytime the astronaut is not in line-of-sight of the LM on the lunar surface.

Changes required to implement a system of this type include those involved in providing a transmit capability at VHF to existing earth based telemetry antenna systems, a new key demodualtor and a new antenna system for the astronauts' backpack communications system.

(NASA-CR-106773) A POSSIBLE VHF BACKUP COMMUNICATIONS BETWEEN EXTRAVEHICULAR ASTRONAUTS ON THE LUNAR SURFACE AND THE EARTH (Bellcomm, Inc.) 6 p

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MEMORANDUM FOR FILE

Now that the first lunar landing has been successfully completed, there is high interest in future exploration missions to the Moon. One constraint that always comes up in discussions on lunar exploration is that implied by the existing extravehicular astronaut (EVA) to Earth communications system. Specifically, the present system will not provide communication between the Earth and an EVA when both EVA's are out of line-of-sight of the Lunar Module (LM). Most mission planners of future scientific missions would like exploration traverses that require both astronauts to be out of line-of-sight of the LM for some period of time. Operations people, at the same time, are generally not willing to have the astronauts out of communication with Earth (MCC) for any siginificant period of time. Several methods of overcoming this constraint have been and are being investigated. Among these are: extensions of the present system (e.g. higher antennas on both the LM and EVA), low frequency surface wave propagation systems using the LM as a relay, direct EVA to Earth systems at S-Band and drop wire systems.

There is a potential mode of operation, using existing EVA systems, that apparently has not been considered. The question that needs answering is what capability exists direct to Earth using the present EVA extravehicular communications system (EVCS)? Obviously, only limited capability, if any, would exist when using the EVCS in a direct to Earth mode since it was originally designed to operate to the LM at a range of a few kilometers.

The EVCS as presently implemented is a VHF system in the 250-300 MHz band that provides communications between astronauts on the lunar surface as well as between the astronauts on the lunar surface and the LM. The LM acts as a relay between the astronauts and Earth enabling two way voice and telemetry from each astronaut to Earth. The telemetry data from each astronaut includes an EKG measurement as well as status data on his portable life support system. One astronaut's EVCS has the capability of relaying voice and telemetry from the other astronaut. This allows one astronaut to go beyond line-of-sight of the LM and continue to communicate with Earth as long as the first astronaut is within line-of-sight of both the LM and second astronaut. The range over which communications can be maintained with the present system is approximately 2.5 km when both astronauts are in line-of-sight of the LM and about 4.5 km when the system is operated in the relay configuration. (This assumes a smooth moon.)

A performance analysis (see Tables I and II)of the present EVCS working directly to Earth shows that usable quality voice can be transmitted from Earth to the EVA from an Earth station equipped with a 60 foot diameter class, antenna system and a one kilowatt transmitter. The up-link channel provided in this manner should be of about the same quality as that now relayed through the LM when the EVA is in line-of-sight of the LM. The transmission capability of the link from the EVA to Earth, however, is very minimal. Table II shows that only a key mode is available again assuming a 60 foot diameter antenna system on Earth. This rudimentary down link would not be able to provide voice and biomedical and PLSS telemetry but the astronaut would be able to transmit by key code information on his status (e.g. AOK) and to readily answer questions asked from Earth. If the PLSS monitoring system is operable and assuming the astronaut can judge his own physical condition, the system suggested here would provide a minimal communications link required to operate for those periods of time when the EVA(S) is out of line-of-sight of the LM as well as a back up for failure of the LM system while an EVA is communicating with Earth using the LM as a relay.

It is likely that the antenna now used with the EVCS would require some modification. The EVCS antanna is a vertically polarized whip with poor radiation characteristics in the direction above the astronaut. A short circularly polarized helix would provide additional gain in this direction. It should be noted that at some sites, such as Tycho and the Marius Hills, the present EVCS antenna would be sufficient because of the low elevation angle of the Earth as seen by the astronaut.

2034-RLS-mbr

R L Selden
R. L. Selden

Attachments
Tables I and II

TABLE I

EARTH TO EVA COMMUNICATION PERFORMANCE AT LUNAR DISTANCE

1.	Transmitter Equivalent Isotropic Radiated Power	Pt dBW
2.	Pointing and Polarization Loss	-2.0dB
3.	Free Space Loss (296.8MHz)	-193.9dB
4.	Receive Antenna Gain	-3.0dB
5.	Receive Circuit Loss	-3.0dB
6.	Total Received Signal Power at Moon	(Pt-201.9)dBW
7.	EVCS Noise Spectral Density (T=2000°K)	-195.6dBW/Hz
8.	Bandwidth Required (6kHz)	37.8
9.	Total Noise	-157.8dBW
10.	Signal to Noise Ratio Required	10.0dB
11.	Modulation Loss (M=1.0)	0.0dB
12.	Total Signal Power Required	-147.8dBW
13.	Earth based EIRP Required	54.1dBW
14.	Transmit Antenna Gain including losses (60')	25.1dB
15.	Required Transmitter Power (P_t)	29.0dBW
		or approx. 1000 watts

TABLE II

EVA TO EARTH COMMUNICATION LINK PERFORMANCE
AT LUNAR DISTANCE

1.	EVCS Transmitted EIRP (Pt= -3.0dBW Lt= -3.0dB)	-6.0dBW
2.	Pointing and Polarization Loss	-2.0dB
3.	Free Space Loss (259.7MHz)	-192.8dB
4.	Receive Antenna Gain (TLM-18)	26.0dB
5.	Receive Circuit Loss	-2.0dB
6.	Total Received Signal	-176.8dBW
7.	Receiver Noise Spectral Density (T=1000°K)	-198.8dB/Hz
8.	Received Signal to Noise Density Ratio (S/N_O) *	22.0dB-Hz
9.	Required S/No for Apollo Key Mode	20.8dB

*No demodulator bandwidth or required signal to noise ratio is shown because a new demodulator would probably be required for this application. The Apollo key demodulator requires a -10.5dB signal to noise ratio in a 1400 Hz bandwidth. A S/N_O of 22.0 would be sufficient signal to operate a linear detector with post detection filtering. (The Apollo demodulator has both a linear and a square law detector.)

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FROM: R. L. Selden

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